SOME ARTIFACTS OF PEER COLLABORATION IN THE LEARNING OF MATHEMATICS

BY

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CONTENTS

ABSTRACT

This study investigated achievement effects when students are paired in the classroom and explored gender and ability effects on achievement in these pairs. Ninety-five rural Grade 11 students from five high schools in two School Divisions and six teachers took part. Classrooms were randomly assigned one of two instructional modes. Students in the experimental classrooms were randomly paired according to gender and ability. Sixteen randomly chosen students from the experimental classes were interviewed at the end of the study. Teachers kept a dated anecdotal record. The results suggest no significant difference in achievement gains when a paired collaborative component is incorporated into instruction. High-females in traditional instruction appear to demonstrate greater gains than high-females in paired situations. Suggestions for further study are made.

CHAPTER ONE

Introduction

Rationale

Instructional modifications suggested in National Council of Teachers of Mathematics Curriculum and Evaluation Standards for School Mathematics (NCTM, 1989) include the following recommendations:

1. "... there be a shift in emphasis from a curriculum dominated by memorization of isolated facts and procedures and by proficiency with paper-and-pencil skills" (p. 125).
2. "... a variety of instructional methods should be used in classrooms in order to cultivate students' abilities to investigate, to make sense of, and to construct meanings from new situations; to make and provide arguments for conjectures; and to use a flexible set of strategies to solve problems" (p. 125).

There are several ways in which the above recommendations can be translated in practise, but the tradition of recommending active learning (Dewey, 1938; Lewin, 1951; Piaget, 1971) suggests that something in the traditional "teacher-centered" classroom inhibits their implementation .

It is possible, of course, that "active learning" does not convey the benefits proposed. But, if one assumes that students learn passively in a traditional classroom and that students learn actively in a peer collaboration setting, then it would be interesting to determine whether achievement as measured by criterion referenced tests is significantly different when comparing these methods of instruction.

The intent of this study is to explore the qualities of student-based active learning in a peer-collaborative arena. The study is made more cogent by the recent heightened interest in peer-collaborative learning.

The study has three intents:

a) To determine the relative effectiveness in a grade 11 mathematics unit of two instructional modes; the traditional one and one which includes a considerable peer collaboration component.

b) To explore the effects of group composition on learning. Students will be paired according to gender and ability in a range of ways.

c) To examine student comments gathered from student interviews and submitted teacher comments for any patterns in student reactions.

Since test scores have considerable historical validity as a measure of achievement, it would be difficult to convince many educators of the viability of an instructional mode that does not at least meet this criterion. At the same time, this study will attempt to assess less quanitative qualities of the method that may be revealed in student interviews.

Definition of Terms

Traditional (direct) teaching is characterized by whole-group instruction with very little free time or unsupervised seat work during class.

Peer collaboration means two students in the same grade work together on the same task with no role definition.

Cooperative learning means groups of students (3-6) in the same grade working together on the same task with role definition.

Student ability means the score on a researcher-made, teacher vetted performance test.

Student reactions means the responses to the interview questions.

High-male means male students who scored in the upper two-thirds on the performance test.

Low-male means male students who scored in the lower one-third on the performance test.

High-female means female students who scored in the upper two-thirds on the performance test.

Low-female means female students who scored in the lower one-third on the performance test.

Performance test means a researcher-made, teacher-vetted test of curriculum objectives of material that all students have previously covered.

Conventional test means a researcher-made, teacher-vetted test of curriculum objectives of material that all students have covered for the particular unit of mathematics chosen for this study.

Disposition refers to a tendency to think and act in particular ways.

Field independent refers to people who perceive situations more analytically.

Field dependent refers to people whose perceptions are easily influnced by social contexts.

Measurement

a) A performance test was administered to provide the basis for separating females and males into high and low performance groups.

b) Conventional tests were used to determine the comparative effectiveness of the instructional modes. These were researcher-made but vetted by the teachers in the study for content validity.

c) Student interviews were conducted. The interviews included but were not be limited to the following questions:

1. What was your experience? (What did you find?)
2. How do you account for your experiences?
3. Would you choose to do this again (work in pairs)? Why or why not?
4. What do you think about learning math this way?
5. If you could change things ... what would you do?
6. Is there anything else you would like to add?

d) Teachers were asked to keep a journal in which they recorded their impressions, thoughts, ideas or unusual phenomena.

<u>Statement of the Problem</u>

a) No statistically significant increases in the score on conventional grade 11 mathematics tests will be obtained with a traditional instructional mode compared to a traditional instructional mode with a peer collaborative component.

null hypothesis, $H_0: u_1 = u_2$

alternate hypothesis, $H_1: u_1 \neq u_2$

b) Different gender and ability matchings will be used to explore any effects on learning.

c) To determine if there is any concurrence between student reactions and the different types of pairings.

CHAPTER TWO

Background and Review of Related Literature

Background

A broad range of questions can be asked about collaborative learning. Among these are; What implementation strategies are the best? What is the nature of the interactions that occur in effective and ineffective pairings? What effect does teacher belief have on implementation? What effects do relevant teacher beliefs have on the interactions between paired students? How does the length of time pairs are together influence learning and other behaviour? What kinds of tasks are best dealt with by pairs of students? What reward systems affect student motivation most in peer collaboration?

It is commonly held that peer collaboration can be a viable adjunct to traditional instruction. "NCTM's Standards calls for a decrease in the instruction by teacher exposition and, instead, 'the use of a variety of instructional formats'(17,p. 129), including small groups, individual explorations, peer instruction, whole class discussions, and project work. It also suggests that increased attention be given to 'active involvement of students in constructing and applying mathematical ideas (17,p. 129)...'" (p. 239). This is supported by studies at elementary and middle school levels (Cobb et al., 1991; Phelps & Damon, 1989), and it is reasonable to assume that the same may be true at the senior level.

The NCTM Standards in grades 9-12 call for mathematics teachers to emphasize problem solving, mathematical reasoning, real-world applications, communication about mathematics, integration of math topics, collaboration among students, and the use of manipulatives and technology. Moreover, teachers must provide experiences that encourage and enable all students to value mathematics and gain confidence in their own mathematical ability (NCTM, 1989).

What is revolutionary about the NCTM Standards is the "fact that they remove computation from the reigning role in the mathematics curriculum" (Willis, 1994, p. 3) and make it subservient to the development of mathematical thinking. Constructivism seems to be the basis for this approach.

What is important is "to consider how to encourage teachers to use their power not to impose their knowledge" (Bishop, 1985, p. 27) on students. If "social interactions are a central component of individual learning" (Schoenfeld, 1989, p. 71), then one of the teacher's primary responsibilities is to provide appropriate instructional activities. Collaborative pairs may provide such an opportunity.

What is giving impetus to these curriculum trends advocated by NCTM? Battista (1994) suggests that "the last 10 years have brought technological advances that have all but eliminated the need for paper-and-pencil computational skill" (p. 463). The Standards suggest that school mathematics needs to be more consistent with accelerating changes in today's society. Usiskin (1985) suggests that "very simple questions involving secondary school mathematics topics are not answered correctly by many students" (p. 90). He also says that "even students who currently do take three years of college preparatory mathematics do not learn the uses of that mathematics" (p. 91). Whatever precise meaning these suggestions are ultimately given, they are creating fundamental changes in mathematics education.

In countries like the Netherlands, Denmark and Australia these changes had already begun in the eighties (de Lange, 1993). In North America "34 states have revised, or are in the process of revising their curriculum frameworks based on the NCTM standards" (Willis, 1992, p. 2). In Canada mathematics curriculums are also being revised. In Manitoba revised mathematics curriculums with instructional modifications consistent with the NCTM standards are currently being implemented at the early and middle school levels. Curriculum changes at the senior level will soon follow. So must senior classroom instruction.

There have yet to be many significant changes in practices at the pre-secondary level. Survey results conducted by Good, Grouws, and Mason (1990) of 1509 elementary teachers indicate that only 5% of those teachers frequently allowed students to work cooperatively with peers. Goodlad's (1984) survey of over 1000 classrooms in 38 elementary and secondary schools indicate that the typical method of instruction consists of lecturing, monitoring students, and conducting quizzes. Seldom were students given the opportunity to learn from each other. It seems inevitable that the implementation of curricula built on The Standards will force major changes at the pre-secondary level. In the not too distant future, students who are only familiar with the new curricula and their subsequent instructional modifications will arrive at senior teachers' door steps.

Davidson (1990) lists some of the main problems that teachers and students perceive may inhibit cooperative learning. It would seem reasonable to take these perceived impediments into account in designings this peer collaboration study. Among them are: concerns about "covering the material", difficulties in forming effective groups, and adjusting to major shifts in role for teachers and students. Among potential advantages he lists: students actively involved at a comfortable pace, improved social skills, relaxed classroom atmosphere, students learn to cooperate, and teachers are often invigorated professionally. Consequently, it could be argued that peer collaboration might represent the least threatening format for the introduction of group work for both students and teachers at the senior level.

Review of related literature

Recent research and other studies concerning peer collaboration in senior classrooms are scant. But there is some evidence from Cobb et al. (1991) and Phelps and Damon (1989) that peer collaboration might facilitate high-order learning in mathematics. In fact, Peterson (1988) also suggests that direct instruction might be insufficient for producing achievement of higher-level skills. These studies were done at lower grade levels. They do suggest, however, the possibility that there may be similar effects at the senior level.

There is little related literature at the senior level on peer collaboration. Most recent work (Webb, 1989) focuses on groups of four students of varying ability. Even in these settings,"... interactions in small groups often took place between two individuals rather than one member addressing the other three students."(Good, Mulryan,& McCaslin, in Grouws, 1992, p. 181)

Davidson (1990) suggests that the opportunity for active participation decreases as group size increases. If this is true, then a group size of two should produce optimum student interaction. Peer collaboration represents one such opportunity.

Further, "the key...[to] peer learning is the child's active participation within a carefully structured context. The child is encouraged to assume responsibility for the pursuit of knowledge and the acquisition of skills. Endowing children with responsibility in this manner itself imparts to them a message that is likely to bolster their enduring confidence in themselves and interest in intellectual achievement."(Damon and Phelps, 1989)

It is important to note that Damon and Phelps paired students for only some, not for all instruction. In their study, students worked in pairs for 20 minutes per class period. This was also the case in the Cobb et al study (1991). That protocol will be maintained in this study. If students were paired for the entire class period and instructed to seek help from the teacher only when necessary, the method would more properly be thought of as a modification of individualized instruction and would be better compared with individualized learning rather than traditional whole-group instruction.

CHAPTER THREE

Methodology

Sample

The sample included a total of 6 classrooms of Math 200 students from two rural School Divisions. The consent of the Superintentents, principals, and affected teachers of these School Divisions was obtained (see Appendix A). The teachers of these classes were volunteers. The informed consent of the parents of the students in these classes was obtained (see Appendix A). A total of 95 students were involved in all (control group: 37 students; experimental group: 58 students).

Two classrooms were randomly assigned to the traditional approach. Student pairs were randomly assigned in the four classrooms receiving the modified treatment. The assignment of these pairs was based on gender and ability.

Instrumentation

A unit of study from the Manitoba Curriculum for Math 200, agreed upon by all the teachers involved in the study, was used. The time frame for the study was 6 weeks and it occurred during the winter.

The unit of study was broken into three subunits with pretests and posttests being administered for each subunit. The curriculum objectives from the Manitoba Curriculum Guide for Math 200 served as guidelines for test item construction. All participating teachers checked the selection of the test items for suitability (see Appendices C, D, E).

Different structural random pairings of students were selected for each subunit (see Appendix J). In addition to allowing for tests of hypotheses, this should partially accommodate any disruption effects caused by conflicts due to personal characteristics. Students were paired with a particular partner for only two weeks. They are thereby more likely to put any personal differences aside and work together for this short duration.

A random selection of four students from each of the four experimental classes were interviewed at the end of the unit of study. In addition, I asked each teacher using the modified treatment to keep a dated anecdotal record of any events or observations that they felt might be of significance. Finally, I asked them for a written account of their overall impressions.

<u>Procedure</u>

Several weeks before the study was to begin I contacted each teacher. This was done to insure that there was agreement on the unit of study, the subunit partitions, and the content of the tests. Teachers were asked to reserve any enrichment that was thought to be important until after the study was completed.

One week before the start of the study, the performance test in mathematics was administered to all students (see Appendix B). The students were ranked in each classroom by their score on this test and the scores were partitioned at the 33 1/3 percentile. The students in the top two-thirds were classified as high and the remaining students were classified as low. See Table 1 for a breakdown of the students in the control and experimental classes.

Table 1

Populations of High & Low Females and Males

	MH	ML	FH	FL*
Experimental	20	18	18	2
Control	11	8	13	5

* MH - males in the top two-thirds.

FH - females in the top two-thirds.

ML - males in the bottom one-third.

FL - females in the bottom one-third.

In the four experimental classes this ranking provided the basis for the assignment of the pairings for each of the three subunits. First, all the low students were randomly paired with high students. Second, the remaining high students were paired. When a class consisted of an odd number of students one group consisted of three students. The results from the students in these groups of three were ignored for the purposes of this study. New pairings were assigned for each subunit and distributed to the teachers involved prior to the start of the new unit of study. Low-low pairings were not included because it was felt unlikely that a teacher would place two students of this calibre in the same learning situation. Some support for this can be found in Hooper & Hannalin (1989). In this study low-ability students completed instruction more efficiently and achievement was stronger in heterogeneous groups than in homogeneous groups. This study investigated the achievement, interaction, and performance of pre-secondary students in cooperative groups during computer-based instruction. See Table 2 for a distribution of the total number of each of the seven different possible pairings.

Table 2

Distribution of Pairings

Pairing Type	Number
MH/ML	25
FH/ML	19
MH/FH	10
MH/MH	6
FH/FH	4
MH/FL	3
FH/FL	2

Absenteeism of students was accommodated by first pairing individual students where possible, and then by assigning any left-over students to other pairs for that day.

The class time available per day was uniformly 45 minutes. In the control group, the teacher introduced the material for the lesson to the whole group by exposition, questions, boardwork, and/or overhead work. The teacher then gave the day's assignment to the students, allowing at least 15 minutes for individual seatwork where possible. The teacher monitored the students and gave help when requested. Corrections came at the end of the class, and if necessary, at the beginning of the next class. This process was repeated except for the first and last days of a subunit when a pretest and posttest respectively were administered.

In the modified (experimental) approach, after writing the pretest, the students were given their pairings and the students sat beside each other, according to the physical circumstances of the particular classroom for all of the succeeding classes for that particular subunit. Students were taught traditionally but in the last 15 minutes of each were instructed to help each other and not to ask the teacher for help unless neither of the students could progress with a problem or answer the other student's questions.

In order to facilitate the role changes for both students and teachers, 10 minutes of the first two lessons of the first subunit was devoted to the following procedure. The same problem (relatively easy to solve) was given to each pair (see Appendices F, G, H). Each pair was assigned a unique identification number and each student in a pair chose to be number one or number two of the pair. They were instructed that the problem had been solved when both students understood the solution. They were to signal the teacher when this point had been reached. When all pairs had solved the problem the teacher randomly picked a pair number and then a student number. The chosen student explained the solution to the rest of the class.

This procedure was designed to encourage the pairs of students working together to experience initial success. Getting the students to work together in this way was intended to reduce any disruption that might exist because the experimental treatment is unfamiliar. Prolonged periods of passive behaviour on the part of students simply because the procedure and what is expected of them would be unfamiliar would vitiate the intended outcomes. Similar training was used in previous research (Hooper, 1992) to promote student interaction. In this study students (singly or in pairs) calculated the number of sides of a three-dimensional figure.

After the last posttest interviews were conducted, a two-tailed t-test was used to determine the significance of the difference between the mean gain scores of the experimental and control groups. The probability of committing a Type I error was set at .05.

For exploratory purposes, further two-tailed t-tests were conducted between the control and experimental groups comparing mean gain scores for ML, MH, FL, and FH in each group. The data gathered was for exploratory purposes only. The results of these additional tests should not be considered supportive of any statistical conclusions.

In addition, mean gain scores were calculated for all ML, MH, FL, and FH students within the experimental group depending on pair makeup. The data gathered was for information and discussion only.

The student interviews and teacher comments were analyzed for patterns in responses. A copy of the transcript is available from the author upon request.

Chapter 4

Results

The scores and their results are presented on Table 3. The raw test scores are found in Appendix I.

Experimental Results

The null hypothesis to be tested by the application of the two-tailed t-test was:

H_0: $U_e = U_c$

Table 3

Average Gains for Experimental and Control Groups

Group	Mean Gain	T value
Experimental	31.1	.67
Control	30.2	

The t-test does not support the rejection of the null hypothesis.

The following analysis presents a further examination of the data. Table 4 compares the average increase test scores for the various gender groups for the experimental and control groups. The exploratory t-tests between the experimental and control groups again showed no significant differences. The outcomes for all experimental gender groups except the high females seemed to favour the treatment.

Table 4

Average Gains

	MH	ML	FH	FL
Experimental	32.6	27.9	31.7	39.3
Control	29.4	22.3	35.9	29.8
t	.99	1.57	1.16	1.05

Within the experimental group low male and low female average gains were compared when these students worked with high males and females. See Table 5 for the results. Low females seemed to prefer working with high males rather than high females. Low females also seemed to work better with high males than their low male counterparts. It should be kept in mind that only two low females were present in the experimental group and that any analysis based on them might well be spurious.

Table 5

Average Gains (Experimental Group)

	MH	FH
ML	9.4	8.4
FL	15.0	7.8

Also within the experimental group, high male and female average gains were compared with scores from their four possible pairings. See Table 6 for these comparisons. It should be noted that high male gains seemed to be marginally greater than high female gains except when high males were paired with high females.

Table 6

Average Gains (Experimental Group)

	MH	FH	ML	FL
MH	11.7	9.2	10.8	9.7
FH	11.1	10.6	10.5	9.0

Student Interviews

In general students found the experimental treatment to be a positive experience. Responses varied from being "OK", "easier", "nothing wrong with it", to being outright supportive. Justification to these responses related to being "on task" or being able to ask for help from not only the other student in the pair but also from other pairs.

Low-males interviewed expressed the most positive responses. Three of them specifically referred to the fact that they preferred this method of instruction and were disappointed that the teacher had reverted to traditional practice. High-males were typically indifferent to the type of instruction. They felt they could work equally well in pairs or alone. Whom they worked with didn't seem to make any difference. One high-male suggested that instructing other students provided the opportunity to learn in new ways.

High-females were supportive of the experimental instructional mode. Their comments were related more to whom they worked with than to the content. Being familiar with the partner surfaced as an important attribute to the pair composition and resultant student interaction. No low-females were interviewed.

Students found this experience to be helpful, likely in part because it was teacher sanctioned. There was a strong reference to equality, the ability of students to help each other. Student concerns were related to passivity on student's part or to the inability of either member in a pair to solve a given problem.

Teacher comments

Teachers were basically supportive of the treatment. There was reference to increased student interaction and "on task" time. Two teachers mentioned that males generally tended to be "off task" more often than females. Two teachers mentioned that mixed gender pairs had the least interaction.

Three teachers mentioned the difficulty of getting pairs to work together. For one teacher this seemed to improve with time. Two teachers indicated that their students already worked collaboratively before the treatment. One teacher mentioned that females were most likely to ask questions of the teacher.

Comparisons

In general, students and teachers were receptive to the treatment. However, teacher and student perceptions were not always parallel for a given class. In one class, even though the teacher said that the students already worked in pairs/groups, two of the interviewed students suggested otherwise. These happened to be low-male students. It is worthy of note that these students sat at tables and were not seated in rows in this classroom.

In another classroom, cultural factors were probably present. Some students in this classroom were reticent. The teacher noticed a lack of two-way communication between some pairs of students. One of the students in these situations was native.

Finally, although interviewed students denied their being any difference between mixed gendered pairs and same sex pairs, two teachers noted decreased communication between mixed gendered pairs. This was evidenced in the teachers' difficulty in encouraging teamwork.

CHAPTER FIVE

Conclusions and Discussion

The results of this study suggest no significant difference in gains between control and experimental groups when a paired collaborative component is incorporated into instruction.

Discussion of Results

There are two reasons why this result should be viewed as exploratory.

First, this study focused on the teaching and learning of quadratics. The study would have to be replicated with other topics and perhaps at other levels before any general inferences could be drawn.

Second, there are no parallel studies of collaborative learning in mathematics at the senior level and few at lower levels. It is therefore not possible at this time to draw even tentative meta-analytical inferences.

It should be noted that students in the experimental group generally favored the treatment and that the teachers noted increased "on task" time. If this is, in fact, a persistent quality of the treatment, it might be expected to enhance performance over a greater time period.

While no hypotheses regarding sex differences and pairings could be tested with this data, an examination of the data suggests that further study of these variables may be productive. In particular, high-females in the control group appeared to demonstrate greater gains than high-females in the experimental group. This could, of course, be attributed to random fluctuations in the data, but it should be noted that students in the control group were free to establish their own seating arrangements and those in the experimental group were not. It is possible that, at least for high-females, this freedom of association may interact with performance.

Limitations of the Study

One must be mindful of the following limitations of this study. First, the control and treatment groups were limited to rural students. The results should be generalized to urban students with caution.

Second, no procedure was invoked to guarantee the fidelity of instructional implementation by the teachers involved in this study.

Third, class sizes were under 20 students, and there is no guarantee that the results would be maintained with class sizes of (say) 30 or more students, which is not an unusual number in an urban setting.

Fourth, the study was carried out in the winter. There is no guarantee that the same results would have occurred if the study had taken place at some other time of the year, when friendships between students might not have yet developed and relationships between students and teachers may not have been established.

Fifth, in at least one classroom cultural differences between students may have influenced the results of the study.

Sixth, all of the treatment classes had an odd number of students. Consequently, one group in each of the subunits for each class consisted of three students. While it is unlikely, this may have influenced subsequent conventional test scores.

Seventh, students in two of the treatment classes normally sat in rows while in the other two classes students normally sat at tables. Being seated at tables may have promoted greater interaction between students than being seated in rows.

Eighth, the sex of the teacher may have interacted with treatment effects. There was no control of this variable in the study. Two of the teachers were male and two were female in this study.

Ninth, the teachers were volunteers and not randomly assigned. Their willingness or enthusiasm may have influenced the results of the study.

Tenth, the designations of high and low female and male do not imply that these categories represent actual student mathematical ability, especially for those students who are near the researcher-chosen demarkation line of the 33 1/3 percentile. For example, a given class might consist of a large number of predominantly weak or average students. Many of them in this study would then be classified as 'high' students. Grouping students by field-dependency, disposition to doing mathematics, or student learning styles all represent possible alternatives for other studies.

Finally this study addressed only the possibility that peer interaction influences student achievement. It was beyond the scope of this study to explore the nature or qualities of peer interaction.

It is distinctly possible that "Without training, students may be unable to interact effectively in small groups" (Hooper, 1992, p. 188). No such interaction techniques were taught in this study. Neither were teachers instructed as to how to facilitate pair interaction. Both of the above may have attenuated the effects of pairs working together, and this may have affected the results of this study.

The observed passivity of some students may be more illusionary than real. If teachers generally felt that there was more interaction and an increase in "on task" time than they normally observed, it is possible that passive behaviour was more likely to be noticed in the experimental group.

Suggestions for further study

Replications of this study might well focus on two parameters: a) specific training for both students and teachers b) the qualities of students, in addition to sex and academic ability, that may interact with the efficacy of collaborative learning.

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Appendix A

Date ________________

To ____________________________

We are about to begin a project involving the Mathematics 200 curriculum, sponsored by a teacher who is a Master's student at the University of Manitoba's Faculty of Education. The thesis advisor is Dr. Eric MacPherson. He can be contacted at the University of Manitoba, Faculty of Education, room 412, phone 474 9070.

It entails exactly the same curriculum and instruction in the subject as is usual, but varies in the way students complete following exercises. Some students will be asked to do that work in pairs. The evidence that we have suggests that students may benefit from that arrangement, but we have no evidence as to what kind of pairings are the most effective. We therefore plan to vary the pairings from time to time and both study the effects of various pairings and seek student views on the practice. The study will take approximately six weeks of school.

The information collected will consist of ordinary test scores and, in some cases, following taped interviews. All of the data will be held in strict confidence. The tapes will be analysed by looking for patterns in student responses to questions that will be asked at the interview. The tapes will then be destroyed to protect student anonymity. Further, any student can withdraw from the pairing arrangements at any time <u>without penalty</u> and can, if he or she should wish, decline to be interviewed without penalty.

If you agree that your child may participate in this project, will you please so indicate below and ask your child to return this form to his or her mathematics teacher. Students who do not return a signed form will complete their seatwork in the traditional way. If your child participates and if you are interested in the results of the study, the researcher will be pleased to provide them. He can be contacted at the following address:

Mr. Greg Lupal
Box 797
Arborg, MB
ROC OAO

I agree that my child may participate in this project

____
Parent or guardian

____
Student

____
Researcher

Date ______________________

Box 797
Arborg, MB
ROC OAO

Office of the Superintendent
_________School Division
Box
___________ , MB

Dear Superintendent:

As part of the requirement for a M.Ed. in Curriculum: Mathematics and Natural Science from the University of Manitoba I am doing a thesis. I am writing this letter seeking permission to gather data from some math classes in your division. My advisor is Dr. Eric MacPherson. He can be contacted at the University of Manitoba, Faculty of Education, room 412, phone 474 9070.

The major objective of my research is to establish whether students working in pairs as opposed to traditional teaching methods represents a viable instructional tool in the current Manitoba Math 200 program.

To the best of my knowledge little research has been done in this area, especially at this level. Whereas in senior science education most students are grouped, at the very least, to do experiments; in math education teachers usually transmit information to the whole class. One of the focuses of my data collection will be to try to ascertain whether or not active learning in paired situations is at least equal to passive learning in traditional teaching. This information has important implications, at least at the senior level, regarding the kind of classrooms envisioned by current recommendations for mathematics teaching and curriculum development as stated in the NCTM publications: <u>Curriculum and Evaluation Standards for School Mathematics</u> and <u>Professional Standards for Teaching Mathematics</u>.

Another focus would be to attempt to identify those parameters, if any, that contribute to group success. This information could serve as the starting point for further investigations.

My proposal will include using some Math 200 classrooms as control situations. In the other classrooms students would be randomly assigned in pairs. I would seek the cooperation of those teachers who have volunteered with regards to curriculum objectives, classroom methodology and test development for the particular unit of study chosen.

I would seek written authorization from the participating students' parent(s) or guardian(s). Data collection in this study will consist of pre and post tests scores, taped student interviews, and teacher comments.

Research subjects may withdraw at any time, without penalty. Student, teacher , and divisional confidentiality will be maintained. Research results will be made available to interested subjects.

The study will require about six weeks of school time.

I have included my home and school phone numbers if any additional information is required.
Home phone number: 376-5665
School phone number: 376-2605

Awaiting your reply, I remain:

Yours sincerely,

Greg Lupal

Box 797
Arborg, MB
ROC 0A0

Dear Principal:

I am a Master's student at the University of Manitoba's Faculty of Education. My thesis advisor is Dr. Eric MacPherson. He can be contacted at the University of Manitoba, Faculty of Education, room 412, phone 474 9070. One of your teacher's has agreed to participate in a study involving the Mathematics 200 curriculum.

The major objective of my research is to establish whether students working in pairs as opposed to traditional teaching methods represents a viable instructional tool in the current Manitoba Math 200 program.

To the best of my knowledge little research has been done in this area, especially at this level. Whereas in senior science education most students are grouped, at the very least, to do experiments; in math education teachers usually transmit information to the whole class. One of the focuses of my data collection will be to try to ascertain whether or not active learning in paired situations is at least equal to passive learning in traditional teaching. This information has important implications, at least at the senior level, regarding the kind of classrooms envisioned by current recommendations for mathematics teaching and curriculum development as stated in the NCTM publications: <u>Curriculum and Evaluation Standards for School Mathematics</u> and <u>Professional Standards for Teaching Mathematics</u>.

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My proposal will include using some Math 200 classrooms as control situations. In the other classrooms students would be randomly assigned in pairs. I would seek the cooperation of those teachers who have volunteered with regards to curriculum objectives, classroom methodology and test development for the particular unit of study chosen.

I would seek written authorization from the participating students' parent(s) or guardian(s). Data collection in this study will consist of pre and post tests scores, taped student interviews, and teacher comments.

Research subjects may withdraw at any time, without penalty. Student, teacher , and divisional confidentiality will be maintained. Research results will be made available to interested subjects.

The study will require about six weeks of school time.

Your signature at the bottom will confirm your teacher's participation in this study. You may return this form to my address. Thanking you in advance, I remain:

Sincerely,

Greg Lupal

Signature

Date

Box 797
Arborg, Manitoba
ROC OAO

Dear Teacher:

Thank you for volunteering to participate in this study. I am a Master's student at the University of Manitoba's Faculty of Education. My thesis advisor is Dr. Eric MacPherson. He can be contacted at the University of Manitoba, Faculty of Education, room 412, phone 474 9070.

This project involves the Mathematics 200 curriculum. It entails exactly the same curriculum and instruction in the subject as is usual, but varies in the way students complete following exercises. Some students will be asked to do that work in pairs. The evidence that we have suggests that students may benefit from that arrangement, but we have no evidence as to what kind of pairings are the most effective. We therefore plan to vary the pairings from time to time and both study the effects of various pairings and seek student views on the practice. The study will take approximately six weeks of school.

The information collected will consist of ordinary test scores and, in some cases, following taped interviews. All of the data will be held in strict confidence. The tapes will be analysed by looking for patterns in student responses to questions that will be asked at the interview. The tapes will then be destroyed to protect student anonymity. Further, any student can withdraw from the pairing arrangements at any time <u>without penalty</u> and can, if he or she should wish, decline to be interviewed without penalty.

You, along with five other teacher volunteers, will be contacted to collectively determine the unit of study. The objectives for this unit will be those from the current Mathematics Curriculum Guide for the Mathematics course. I will submit to you the requisite tests for your approval and change where necessary.

You will be randomly assigned to a control or experimental group. In control classrooms, traditional instruction will be followed by 15 minutes of seatwork. In experimental classrooms, students will be randomly paired and traditional instruction will be followed by 15 minutes of seatwork.

You will also be asked for any comments regarding your experience in this study. Your identity will be protected in this study. Results will be circulated to you after the data has been analyzed.

Your signature at the bottom will confirm your participation in this study. You may return this form to my address. Thanking you in advance, I remain:

Sincerely,

Greg Lupal

Signature

Date

Appendix B

Math 200 Test

1. Draw the graph of the equation $y = -2x + 5$

2. Write an equation in standard form of the line that passes through the points A(-3,2) and B(-4,4).

3. Find the distance between points P(-1,-7) and Q(7,-3). Give the answer in simplest radical form.

4. Write an equation in standard form, of the line that passes through the point N(-4,1) and is perpendicular to a line whose equation is $5x - 2y = 10$

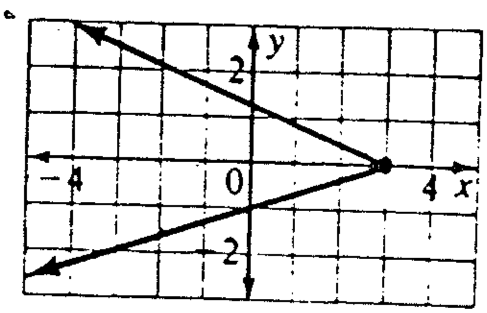
5. Solve the following system of equations.

$$\begin{aligned} -2x + 3y - 2z &= -1 \\ -3x + 2y - z &= -5 \\ 4x - 3y + 2z &= 5 \end{aligned}$$

6. Graph $3x < x - 4$ or $5x - 3 > 7$ on a number line.

7. Graph $y = |x|$

8. Determine the domain and range of the following relation whose graph is given below. Is the relation a function? Why?



9. Let $f(x) = 2x - 3$ and $g(x) = x^2 - 2$

Find the following: a) $f(2) - g(3)$ b) $f(g(-3a))$

Appendix C

Math 200 Test1 Quadratics

1. Determine the roots of the following quadratic equations without using the quadratic formula.

a. $12x^2 - 9x = 0$

b. $3n^2 - 15n + 18 = 0$

c. $-3c^2 = c - 2$

d. $36a^2 - 25 = 0$

2. Solve using the quadratic formula.

a. $2x^2 - x - 5 = 0$

b. $5a - 1 = 4a^2$

c. $y^2 + 5 = 6y$

3. Solve the following equations.

a. $\sqrt{3a + 1} - \sqrt{a - 4} = 3$

b. $\dfrac{2n - 9}{n - 7} + \dfrac{n}{2} = \dfrac{5}{n - 7}$

Appendix D

Math 200 Test2 Quadratics

1. Write a quadratic equation whose solution is - 7 and 1.

2. Write a quadratic equation in standard form whose roots are - 3/4 and - 5/8 .

3. Determine the real zeros for the following quadratic function:

$$y = 2x^2 + 12x + 13$$

4. Determine the number of real roots for the following equations without solving the equation .

a. $3y^2 = 4y - 2$

b. $x^2 + 5x - 3 = 0$

c. $\frac{3x^2}{2} - 2x + \frac{2}{3} = 0$

5. Sketch the following quadratic function by finding the vertex and the x - intercepts.

$$y = x^2 + 8x + 6$$

Appendix E

Math 200 Test3 Quadratics

1. Solve the following system graphically.

$$y = x^2 - 9$$

$$x + y = 3$$

2. Solve the following system algebraically.

$$y = x^2 - 7x - 3$$

$$2x - y = 3$$

3. Do any three of the following problems.

a. A picture 10 dm x 12 dm is to be placed on a background panel for display. How large a uniform border must be left around the picture so that the resulting rectangular panel has an area three times the area of the picture.

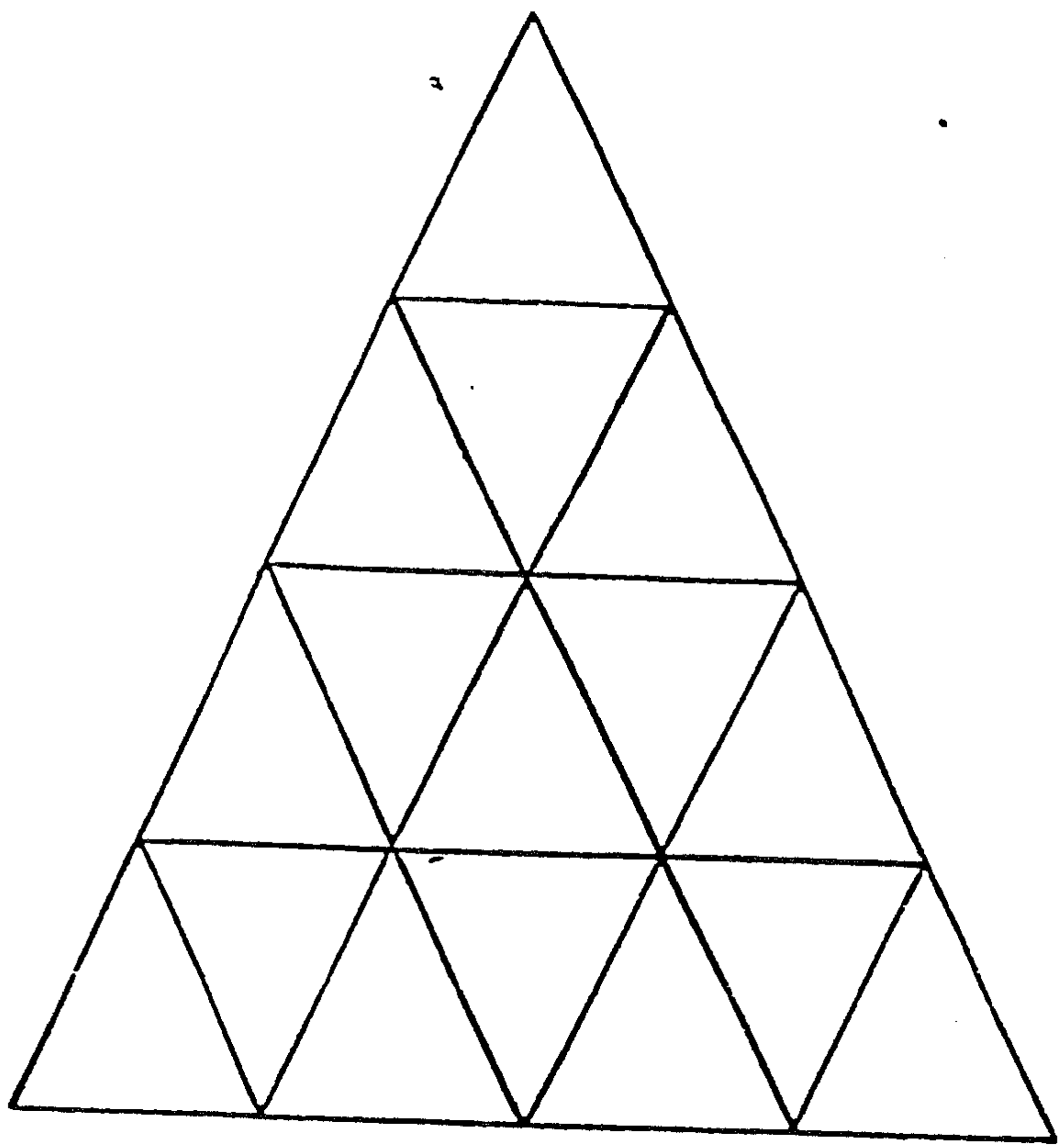
b. If the price of oranges rises 10 cents per dozen, a person will be able to buy two dozen fewer oranges with $6.00 than was possible at the original price. What was the original price?

c. The product of two numbers is 33. One number is two more than three times the other number. Find both numbers.

d. Some chocolates are placed in a box, and the boxes are then packed in cartons. The number of chocolates in each box is eight times the number of boxes per carton. If there are 1152 chocolates per full carton, how many chocolates per box?

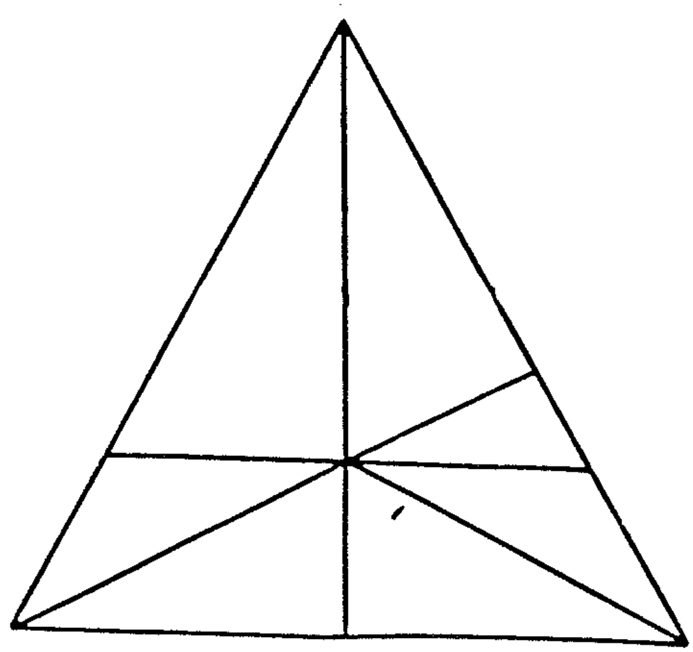
Appendix F

How many triangles in the following diagram?



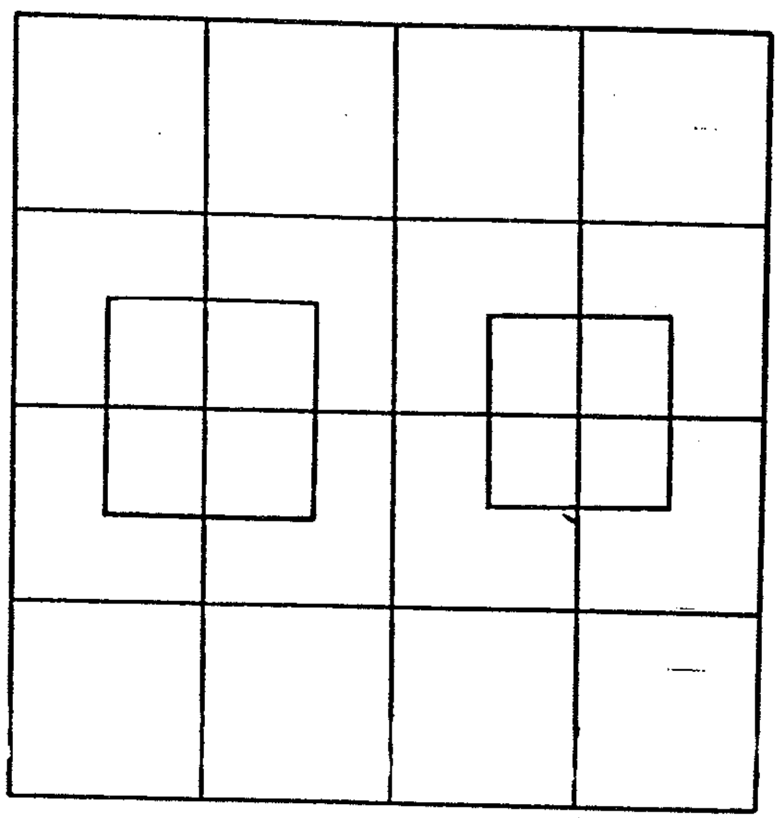
Appendix G

How many triangles in the following diagram?



Appendix H

How many squares in the following diagram?



Appendix I

Test Scores (Experimental Group)
Class 1

Student	Type	Performance Test	Test 1 Pre	Test 1 Post	Test 2 Pre	Test 2 Post	Test 3 Pre	Test 3 Post
1	ML	9	0	10.5	1.5	13.5	2.5	10
2	ML	10.5	0	16	2	7.5	10	11.5
3	ML	10	0	21	1	16.5	2.5	13.5
4	FL	7	0	20	0	12.5	5	17.5
5	ML	10.5	0	15	1	12	1.5	18
6	FH	19	0	19	3	15.5	0	16.5
7	MH	17	0	17	1.5	9	0	10
8	MH	14	0	15	0	7	6.5	20
9	FH	14	0	18	0	18	7.5	10
10	MH	17	0	19	0	3	0	12
11	MH	22.5	0	17	3	18	5	25
12	MH	15.5	0	16	0	5	0	17
13	MH	22	0	19	1	16	5	10
14	MH	14.5	0	20	5	18	10	25
15	FH	21	0	21	3	16.5	7.5	20

Test Scores (Experimental Group)
Class 2

Student	Type	Performance Test	Test 1 Pre	Test 1 Post	Test 2 Pre	Test 2 Post	Test 3 Pre	Test 3 Post
1	ML	6	7	13.5	4	11	8	13
2	FH	15.5	13	17	10.5	16	8	11.5
3	MH	24	15	22	12	18	15	25
4	ML	7.5	3	8	0	8	0	7
5	FH	24.5	13	21	11	16.5	12	23.5
6	FH	19	13	17.5	12	18	7	17.5
7	MH	11	6	13	6	8.5	1.5	11
8	MH	14	9	18	7	15.5	0	13
9	MH	10	8	13.5	2.5	10	4	6.5
10	ML	8.5	0	12	6.5	12	0	14.5
11	MH	18	14	20.5	13	17.5	10	25
12	MH	15.5	11	16.5	9	15	2	14
13	ML	7	3	10	4.5	13.5	0	11
14	FH	17	10.5	16	10	16.5	4	15
15	ML	7	9	16.5	8	13.5	0	5

Test Scores (Experimental Group)
Class 3

Student	Type	Performance Test	Test 1		Test 2		Test 3	
			Pre	Post	Pre	Post	Pre	Post
1	MH	13.5	6	10.5	3	15	4	23
2	ML	10.5	3	12	5	12.5	1	19
3	ML	9	1	10	4	14	2	11
4	MH	13	3	15	2	11.5	5	16.5
5	FH	15.5	11	14.5	0	9	1	16.5
6	MH	24	11	19	7	18	3.5	23.5
7	FH	23.5	11	18	10.5	18	3	18.5
8	MH	16.5	3	16.5	3	14	3	15.5
9	ML	10.5	4	9.5	3	14.5	3	13.5
10	FH	12.5	7	15	3	16.5	3	17
11	ML	7	3	9	0	10	2.5	10
12	FH	15.5	3	18	6.5	15.5	4.5	17
13	FH	21.5	12	19.5	8	10.5	7	16.5
14	MH	17	3	7	6	11	7	17
15	ML	6.5	2	5	0	10	2.5	19

Test Scores (Experimental Group)
Class 4

Student	Type	Performance Test	Test 1		Test 2		Test 3	
			Pre	Post	Pre	Post	Pre	Post
1	FH	20	3	13.5	14.5	18	16	23
2	FH	16	1.5	8	9.5	9.5	1	20
3	ML	9.5	2	17	9	8.5	5	14.5
4	MH	11.5	1.5	11	0.5	8	1	10.5
5	ML	8	2	5.5	1	11.5	3.5	11.5
6	FH	16.5	2.5	16.5	12	18	3	23.5
7	FH	21	4	15	10	16.5	2	22.5
8	FL	5.5	1.5	8	3	12	1.5	19.5
9	ML	6	1.5	15.5	2	12	1	13
10	FH	15	4.5	16.5	6	17.5	4	23.5
11	MH	12.5	4.5	13.5	1	14.5	2.5	23
12	FH	15.5	4	15.5	8.5	15.5	3	22
13	ML	11	4	9	6	11.5	3	11.5

Test Scores (Control Group)
Class 1

Student	Type	Performance Test	Test 1 Pre	Test 1 Post	Test 2 Pre	Test 2 Post	Test 3 Pre	Test 3 Post
1	FH	25	4	22	5	17.5	6	22
2	MH	11.5	0	12.5	3	15	0	13.5
3	MH	13.5	0	7.5	2	16	0	3
4	MH	9.5	0	12	1	15.5	0	5
5	FH	16.5	0	21	5	16	3	18.5
6	FH	25	2	20.5	7	18	1	22
7	MH	10	0	7.5	0	11.5	0	7
8	FH	16.5	0	9.5	3.5	14	4	17
9	FH	7.5	1	9.5	2	17	1	10.5
10	MH	13	4	4.5	4	15.5	0	14
11	ML	7	1	3.5	0	15.5	0	5.5
12	FH	22	0	14	3	16.5	7	20
13	MH	14	0	9.5	2	12	0	11
14	ML	4.5	1	6	0	11.5	3	0
15	ML	1	0	0	2	7.5	0	2
16	ML	6	1	6	2	12.5	0	11.5
17	MH	13	0	6.5	2	15	0	6
18	FH	12.5	2	13	3	13.5	0	5
19	MH	12	0	11	2	12.5	0	14

Test Scores (Control Group)
Class 2

Student	Type	Performance Test	Test 1 Pre	Test 1 Post	Test 2 Pre	Test 2 Post	Test 3 Pre	Test 3 Post
1	FH	12	0	18	7	17	2	18
2	MH	12	4	9	5	12.5	1	9
3	MH	7	0	13	2	8.5	3.5	8
4	MH	8	0	15.5	9	17	4	14
5	FL	4	0	17.5	4	16	2	17
6	FH	10	4	13.5	5	12	2	15
7	ML	1	0	12	0	11.5	1	10
8	FH	15	4	19.5	9	18	1	17
9	ML	3	3	15.5	8	12	6.5	7
10	FH	6	3	11	8.5	16	2	11
11	FH	13	9	21	11	15	3	16
12	FH	18	12	22	14	18	18	25
13	FH	10	0	16	8	13.5	1	17
14	FL	3	1	7	0	6	0	5
15	FL	.5	0	19	7.5	17	2	8
16	FH	11	0	18	13.5	16	3	12
17	MH	10	5	16.5	5.5	14	3.5	16
18	FL	5	3	11	4	10	1	7

Appendix J

Student Numbers of Experimental Pairs

	Class 1	Class 2	Class 3	Class 4
Test 1	11-1	1-5	2-1	3-11
	15-5	15-2	3-6	5-12
	7-4	4-12	11-13	9-1
	10-3	10-14	15-12	8-7
	13-14	3-8	4-8	2-10
	6-12	11-9	7-14	
Test 2	2-13	10-12	2-5	13-2
	5-12	4-8	3-8	3-10
	1-6	13-3	15-4	5-6
	4-8	15-7	6-10	8-12
	9-10	1-11	13-1	11-1
	11-7	6-9	9-12	
Test 3	2-7	10-3	9-6	13-11
	3-8	4-2	2-8	3-2
	1-12	13-7	3-5	5-1
	4-13	15-11	11-4	9-6
	15-9	8-6	7-10	4-12
	10-14	9-5	13-12	